The Entropy Evaluation Method for the Thermodynamical Selection Rule

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Abstract

The authors have proposed the thermodynamical genetic algorithm (TDGA), which can maintain the diversity by evaluating the entropy of the population. In this paper, the authors discuss techniques to approximate the value of entropy.

1 Introduction

The authors have proposed a selection rule for the genetic algorithm (GA) called the thermodynamical genetic algorithm (TDGA)[1] which controls diversity by evaluating the entropy of the population and by selecting population so as to minimize the free energy.

In this paper, the authors propose two novel approximation techniques of entropy. The effectiveness of the proposed methods is confirmed by computer simulation taking an Nk-landscape model as an example.

1.1 Calculation of the Entropy

In the TDGA, the selection operation is designed to minimize the free energy of the population. The free energy F is defined by:

$$F = \langle E \rangle - HT, \tag{1}$$

where $\langle E \rangle$ is the mean energy of the population, H is the entropy and T is a parameter called the temperature.

The TDGA utilizes an approximation of the entropy H^1 which is evaluated in a locus-wise manner to cope with the problem that the population size is much smaller than the number of the possible species[1]. However, in some situation, only a few individuals are selected because of the above approximation. To avoid this problem, we propose the following two approximate value of entropy.

1. Entropy $H^{\mathrm{sub},n}$ which is evaluated based on the substrings of a length n instead of locus-wise evaluation.
2. Entropy H^n which is evaluated based on all combinations of n loci.

2 Computer Simulation

We use an Nk-landscape model[2, 3] as an example. In this paper, we set $N = 20$ and $k = 1,\ 2,\ 4,\ 8,\ 16$.

The Nk-landscape model is solved by TDGA. Four entropy, H^{ALL}, H^1, $H^{\mathrm{sub},2}$ and H^2 are used in the TDGA. H^{ALL} is general entropy which is evaluated based on species.

The result of the computer simulation shows that the best performance is obtained by TDGA with H^2, and the performance of TDGA with $H^{\mathrm{sub},2}$ is superior to that of TDGA with H^1 in all k.

Computation time of H^{ALL}, H^1 and $H^{\mathrm{sub},2}$ is almost the same, while that of H^2 is bigger than other three.

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